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Description

This invention relates to heat exchangers and, in particular to a heat exchanger assembly adapted for automotive or other air conditioning evaporators or condensers.

Where a heat exchanger utilizes a working fluid which exists in both the gaseous and liquid phase, heat transfer performance can be limited by excessive working fluid pressure drop in those areas where the gaseous phase working fluid is found. In a heat exchanger which operates as a condenser, this problem of pressure drop occurs in the inlet section; in a heat exchanger which operates as an evaporator, it is found in the outlet section.

In a condenser-type heat exchanger, pressure drop that occurs in the inlet section reduces the saturation temperature by an amount proportional to the pressure drop. This has the effect of reducing the temperature potential driving the exchange of heat from the internal fluid to the second working fluid (e.g., air) passing over the outside of the primary and secondary surfaces. In typical applications, these surfaces are the tubes and associated fins through which the working fluid passes. Efforts which have been employed to reduce pressure drop include multiple inlet feeds and manifold assemblies, which add cost and complexity and reduce the overall assembly reliability by virtue of increasing the number of variables in the production process.

In an evaporator-type heat exchanger, excessive pressure drops in the internal fluid path on the outlet side have a similar consequence, i.e., reduction in the temperature potential available to absorb heat from the air stream passing over the exterior of the heat exchanger tubes and fins.

Furthermore, use of heat exchangers in automotive (including truck and other motor vehicles) applications, such as air conditioning systems, requires that such units be compact, low in weight and highly efficient in order to meet the increasingly restrictive specifications in modern motor vehicle technology.

In this field US-A-4.831.844 discloses a condenser for a refrigeration system wherein the structure provided for facing the problem of the pressure drop is rather complicate and bulky.

Indeed the flow path from the inlet port to the outlet. port includes a first and a second section connected to each other wherein the refrigerant flows part way from the inlet port to the outlet port in plural paths and flows the remainder of the way to the outlet port in one path. More precisely each tube of the first section is doubled in parallel with an identical tube while the second section, of less length comprises only single tubes, the tubes of both first and second section having the same diameter.

As already stated this structure is very complicated, expensive and unduly bulky.

Bearing in mind the problems and deficiencies of the prior art, it is therefore an object of the present invention to provide a heat exchanger assembly which minimizes the pressure drop associated with a dual phase working fluid in the gaseous phase.

It is another object of the present invention to provide a solution to the aforementioned problem of gaseous fluid pressure drop which can be utilized in both evaporators and condensers.

It is a further object of the present invention to provide a heat exchanger which meets the aforementioned objects and which is compact in configuration, low in weight and does not introduce unnecessary complexities in manufacturing.

It is yet another object of the present invention to provide a heat exchanger assembly which minimizes gaseous phase pressure drop of a dual phase working fluid which is especially suitable for use in automotive and other industrial, commercial or residential applications.

It is a further object of the present invention to provide a heat exchanger which may be utilized in various applications and which provides higher efficiencies over conventional industrial, commercial, residential or automotive type heat exchangers.

The above and other objects, which will be apparent to those skilled in the art, are achieved in the present invention which provides a heat exchanger assembly comprising a pair of header members and a plurality of heat-transfer tubes passing between the header members. The heat transfer tubes are adapted to transfer heat between fins on the exterior of said tubes and a working fluid in liquid or gaseous phases within the tubes. A gas pressure drop minimizing tube passes between the headers through the working portion of the heat exchanger and has a cross sectional area significantly larger than the other heat transfer tubes. The gas pressure drop minimizing tube is adapted to carry the working fluid in a gaseous phase either as an inlet, when the heat transfer assembly is utilized as a condenser, or as an outlet, when the heat transfer assembly is utilized as an evaporator. A member connects the pressure drop minimizing tube at one end to at least one of the heat transfer tubes for either transferring gaseous working fluid from the pressure drop minimizing tube to the heat transfer tubes for condensation to a liquid, when the assembly is utilized as a condenser, or transferring gaseous working fluid from said heat transfer tubes to the pressure drop minimizing tube, when said assembly is utilized as an evaporator. A plurality of return bend tubes connect the heat transfer tubes to one another to carry the working fluid through the assembly.

The assembly preferably utilizes straight heat transfer tubes between the headers which are circular and have substantially the same interior cross-sectional area, and includes the pressure drop mini-

mizing tube within the heat transfer tube array and within the fin pattern imposed upon the heat transfer tubes.

Fig. 1 is a front elevation view of the present invention, without the cooling fins, utilized as an automotive condenser.

Fig. 2 is a detailed view of a portion of the front of the condenser of Fig. 1 showing the fin array on the condenser tubes.

Fig. 3 is a side elevation view of the condenser of Fig. 1 mounted in front of an automotive engine radiator.

Fig. 4 is a side schematic view showing the working fluid circuit through the condenser of Fig. 3.

Fig. 5 is a side schematic view showing the circuit of a working fluid through an automotive evaporator constructed according to the present invention.

The components of the present invention are preferably made of lightweight, thermally conductive material such as aluminum, although it should be noted that the high thermal efficiency and other advantages of the present invention, as compared to the prior art, are due primarily to its novel features and configuration. Other metals and alloys may also be used, for example, copper, brass and stainless steel, depending on the application. The components are joined in a conventional manner such as by welding, brazing, soldering or the like. Among the various drawings described below, like numerals identify like features of the invention.

In Figs. 1 and 2, there are shown views of the front of the present invention in an embodiment for use as an automotive air conditioner condenser. As shown in Fig. 1, without the cooling fins installed, condenser 10 comprises a series of straight, circular cross-sectioned heat transfer tubes 12 extending horizontally and parallel between spaced vertical headers 14 and 16. Header support members 28 on either side of the condenser 10 receive the ends of condenser tubes 12. Headers 14 and 16 include header return bend tubes 18, 20 and 21 which connect the various tubes 12 and transfer the working fluid, in this case, a conventional dual-phase refrigerant, from one tube to the next. As shown (fig. 1) header tubes 18 are included in header members 14 and 16 and connect heat transfer tubes 12 to convey the working fluid. Inlet tube 22 and outlet tube 24 provide fluid connection between the condenser 10 and other components (not shown) of the automotive air conditioner unit through free ends 22' and 24', respectively.

All refrigerant enters condenser 10 through inlet end 22' and passes through the entire length of the corresponding condenser inlet tube 22 whereupon it is split into two separate fluid circuits by an "M" shaped return bend tube connecting member or pod 20 which has one inlet 23 and two outlets 19 (Fig. 2). "U" shaped return bend tubes 18, each having one inlet and one outlet, direct the refrigerant flow in each circuit from one tube 12 to the next, as shown in Figs. 1 and 2. In the embodiment shown, the tube rows are staggered between the front and rear of the condenser. Except at the top and bottom, the header tubes connect front tubes to front tubes and rear tubes to rear tubes. The two separate fluid circuits are reunited from separate heat transfer tubes 12 by an "M" shaped return bend tube member or pod 21 which has two inlets and one outlet. The combined flow of working fluid is directed through outlet tube 24 and out through end 24' to the other portions of the air conditioner unit (not shown).

As shown in the detail of Fig. 2, an array of individual fin units 30 are shown arranged in a parallel fashion with the plane of each fin being vertically aligned perpendicular to the face of the condenser 10 and parallel to the direction of air flow therethrough. The fins 30 extend in an array and cover the entire core area of the condenser between the header supports 28. To achieve the desired convective cooling efficiencies, the fins 30 are fitted tightly over tubes 12, 22 and 24 or are otherwise bonded thereto in a manner which promotes conductive heat transfer between the tubes and the fins. Each fin 30 extends essentially completely across the depth of the condenser 10 to maximize contact with the air flowing through the unit.

A side view of the condenser 10 of Figs. 1 and 2 is shown positioned in front of an automobile radiator 26 in a typical configuration. Air flow is shown in the direction of the arrows in Fig. 3.

In the condenser embodiment depicted in Figs. 1, 2, and 3, the working fluid typically enters a condenser 10 in a gaseous phase, having absorbed the heat from the passenger or other portion of a vehicle through an evaporative-type unit. To reduce the pressure drop of the incoming gaseous refrigerant, and to minimize the reduction of saturation temperature thereof, inlet tube 22, along with associated tube ends 22' and header tube inlet 23, have an internal cross-sectional area which is uniform and sized significantly larger than the cross-sectional area of the individual heat-transfer tubes 12 and outlet tube 24 in the circuits which they feed. Preferably, the internal cross sectional area of the entire pressure drop minimizing tube 22', 22 and 23 is at least about 10% larger, and more preferably at least about 15% larger, than the internal cross sectional area of the remaining tubes in the assembly. These remaining tubes 12, 18, 19, 21 and 24 all have approximately the same internal diameter and cross sectional area. As shown pressure drop minimizing tube 22 also acts as a heat transfer tube and accordingly extends between said header members (14,16) within the array of said heat transfer tubes (12) and fins (30).

The provision of a larger internal cross-section in pressure drop minimizing tube 22 reduces the pres-

sure drop which would otherwise be experienced in a heat transfer assembly utilizing an inlet tube having the same size as other tubes 12, 18 and 24, without elaborate manifolding or other complexities. Also, in accordance with the preferred embodiment of the present invention, the pressure drop minimizing tube 22 lies within the general pattern of tubes 12 and fins 30. In a typical application as shown in Figs. 1-3, heat transfer tubes 12, including tube 24 and end 24', have a diameter of 6,86 mm and a wall thickness of 0,63 mm Inlet tube 22, along with tube end 22' and "M" pod inlet 23 would have a diameter of 9,40 mm and a wall thickness of 0,81 mm and is approximately 90% larger in interior cross sectional area.

In Fig. 4 there is shown an end-wise "circuit diagram" of the flow path of working fluid through the various heat transfer tubes and header tubes described in connections with Figs. 1-3. Heat transfer tubes 12, inlet tube 22 and outlet tube 24 are shown in cross section. The location of the connecting header tubes are shown connecting tubes 12, 22 and 24 in either solid line, to depict the header tubes on the near side of the condenser 10, or dashed lines, to depict the header tubes on the far side of the condenser 10. These connecting header tubes are identified by adding the letter "a" to those tubes on the near side (e.g. 18a) and the letter "b" to the header tubes on the far side (e.g. 18b) of condenser 10.

A side schematic of a "circuit diagram" of a preferred embodiment of the present invention as utilized in an automotive type evaporator is shown in Fig. 5. In this embodiment, the evaporator structure is basically the same as that of the condenser, except that the inlet and outlets are reversed and the configuration of the header tubes includes more rows from front to back. Evaporator 32 includes a plurality of parallel circular cross-section heat transfer tubes 34 extending in five staggered rows (front to back) between headers (not shown). Parallel inlet tube 33 serves to introduce condensed, liquid refrigerant through its near end (as seen in Fig. 5) and has the same size and cross-sectional area as the other heat transfer tubes 34. Inlet tube 33 is connected at the far end of condenser 32 (as seen in Fig. 5) by a tripod-type connecting header tube 36b to two other heat transfer tubes 34. The working fluid, which is divided into two separate circuits, then passes through the various heat transfer tubes and similar sized "U" shaped connecting header tubes 38a (shown as solid lines connecting header tubes 34) at the near end of evaporator 32 or by "U" shaped connector tubes 38b (shown as dashed lines connecting heat transfer tubes 34) at the far end of evaporator 32.

After passing through the various heat transfer tubes 34 and headers 38, the two separate fluid circuits are reunited with the refrigerant in a partially or fully gaseous phase, and exit evaporator 32 the near end of outlet tube 39. In accordance with the present invention, parallel, circular outlet tube 39 is a pressure drop minimizing tube of uniform and significantly larger interior cross-sectional area than the remaining heat transfer tubes 34. A tripod-type, three-legged connecting header tube 35b joins the working fluid from two separate heat transfer tubes 34 at the far end of evaporator 32 into a single stream which then passes through pressure drop minimizing tube 39 and out of the evaporator at the near end. In the two-circuit embodiment shown, evaporator outlet tube 39 has an approximately 15% larger cross-sectional area than the remaining tubes 33 and 34. As in the condenser embodiment shown in Figs. 1-4, outlet tube 39 serves to reduce the pressure drop of the gaseous refrigerant passing therethrough and thereby minimizing the reduction of temperature potential available to absorb heat from the air stream passing over the exterior of the heat exchanger.

As with the condenser embodiment, the evaporator 32 has a staggered tube configuration, as seen from the front (with five (5) rows of tubes instead of two), and has a cooling fin array imposed over the tubes 33, 34, and 39. By incorporating the pressure drop minimizing tube 39 in the fin and heat transfer tube pattern within the working portion of the heat exchanger, considerable complexity in manifolding is eliminated, thereby improving assembly reliability and lowering cost.

The evaporator embodiment depicted in Fig. 5, when utilized with an outlet tube size of 15,9 mm diameter and remaining tube size of 12,7 mm diameter, has shown considerably increased heat transfer over a similar evaporator utilizing an outlet tube having the same diameter as the remaining tubes. In a typical automotive evaporator assembly, the increase has been shown to be approximately 756 Kilo calories per hour.

Thus the present invention may be utilized in either a condenser mode where a partially or fully gaseous working fluid is being condensed to a liquid, or in an evaporative mode where a liquid working fluid is partially or fully vaporized to a gas. In either case, the primary tube of the heat exchanger carrying the partially or fully gaseous phase either into or out of the unit is of significantly larger cross-sectional area than the majority of the remaining tubes of the unit.

Claims

1. A heat exchanger assembly to be utilized in an air conditioning system to be used as a condenser or an evaporator comprising:
   a pair of header members (14,16);
   a plurality of heat transfer tubes (12) extending between said header members (14,16);
   a plurality of header tubes (18) included in said header members (14,16) and connecting said

heat transfer tubes (12) to convey said working fluid;
a plurality of convective cooling fins (30) forming an array over said heat transfer tubes (12), said heat transfer tubes (12) and fins (30) adapted to transfer heat between the exterior of said tubes and fins (12,30)and a working fluid in a gaseous or liquid phase within said tubes (12);
characterized in that it also comprises a pressure drop minimizing tube (22) extending between said header members (14,16) within the array of said heat transfer tubes (12) and fins (30) and connected to said heat exchanger assembly, said pressure drop minimizing tube (22) having a cross sectional area larger than the sectional area of each of said heat transfer tubes (12) and conveying said gaseous working fluid to and from said heat exchanger assembly and a tube member (23) connecting said pressure drop minimizing tube (22) at one end to at least one of said heat transfer tubes (12) for either transferring a gaseous working fluid from said pressure drop minimizing tube (22) to said heat transfer tubes (12) for condensation to a liquid, when said assembly is utilized as a condenser, or transferring gaseous working fluid from said heat transfer tubes (12) to said pressure drop minimizing tube (22) when said assembly is utilized as an evaporator.

2. The assembly of claim 1, wherein said pressure drop minimizing tube (22) and said connecting tube member (23) have the same cross sectional area.

3. The assembly of claim 1, wherein said pressure drop minimizing tube (22) extends parallel to said array of heat transfer tubes (12).

4. The assembly of claim 1, wherein the cross sectional area of said pressure drop minimizing tube (22) is at least 10% larger than the internal cross sectional area of the said heat transfer tubes (12).

Patentansprüche

1. Ein Wärmetauscher, nutzbar als Kondensator oder als Verdampfer zur Anwendung in einem Luftkonditionierungssystem, bestehend aus:
einem Paar Kopfteilen (14, 16);
einer Mehrzahl von Wärmeübertragungsrohren (12), die sich zwischen den Kopfteilen (14, 16) erstrecken,
einer Mehrzahl von zu den Kopfteilen (14, 16) gehörenden Kopfrohren (18), die die Wärmeübertragungsrohre (12) für die Förderung des Betriebsmittelfluids verbinden,
einer Mehrzahl von Konvektionskühllamellen (30), die in Reihe auf den Wärmeübertragungsrohren (12) nebeneinander angeordnet sind; diese Wärmeübertragungsrohre (12) und die Lamellen (30) sind bestimmt für die Wärmeübertragung zwischen der Umgebung der Rohre und Lamellen (12, 30) und einem gasförmigen oder flüssigen Fluid in den Rohren (12);
dadurch gekennzeichnet,
daß er auch ein Druckminderrohr (22) enthält, das sich zwischen den Kopfteilen (14, 16) innerhalb der Reihe von Wärmeübertragungsrohren (12) und den Lamellen (30) erstreckt und mit dem Wärmetauscher verbunden ist, das Druckminderrohr (22) hat einen Querschnitt, der größer ist als der Querschnitt jedes der Wärmetauscherrohre (12) und fördert das gasförmige Betriebsmittelfluid zu und aus dem Wärmetauscher, und ein Rohrteil (23) verbindet das Druckminderrohr (22) an einem Ende mindestens mit einem der Wärmeübertragungsrohre (12) für entweder die Überleitung eines gasförmigen Betriebsmittelfluids aus dem Druckminderrohr (22) in die Wärmeübertragungsrohre (12) für die Kondensation in eine Flüssigkeit, wenn der Tauscher als Kondensator verwendet wird, oder die Überleitung eines gasförmigen Betriebsmittelfluids aus den Wärmeübertragungsrohren (12) in das Druckminderrohr (22), wenn der Tauscher als Verdampfer verwendet wird.

2. Der Tauscher nach Anspruch 1, worin das Druckminderrohr (22) und der Rohrteil (23) den gleichen Querschnitt haben.

3. Der Tauscher nach Anspruch 1, worin sich das Druckminderrohr (22) parallel zur Reihe der Wärmetauscherrohre (12) erstreckt.

4. Der Tauscher nach Anspruch 1, worin der Querschnitt des Druckminderrohres (22) mindestens 10% größer ist als der innere Querschnitt der Wärmeübertragungsrohre (12).

Revendications

1. Ensemble d'échange de chaleur destiné à être utilisé dans un système de conditionnement d'air, pour servir de condensateur ou d'évaporateur et comprenant:
   - une paire d'organes collecteurs (14,16);
   - une pluralité de tubes de transfert de chaleur (12) s'étendant entre lesdits organes collecteurs (14, 16);
   - une pluralité de tubes collecteurs (18) inclus dans lesdits organes collecteurs (14,

16) et reliant lesdits tubes de transfert de chaleur (12) pour transporter ledit fluide de service ou de travail.

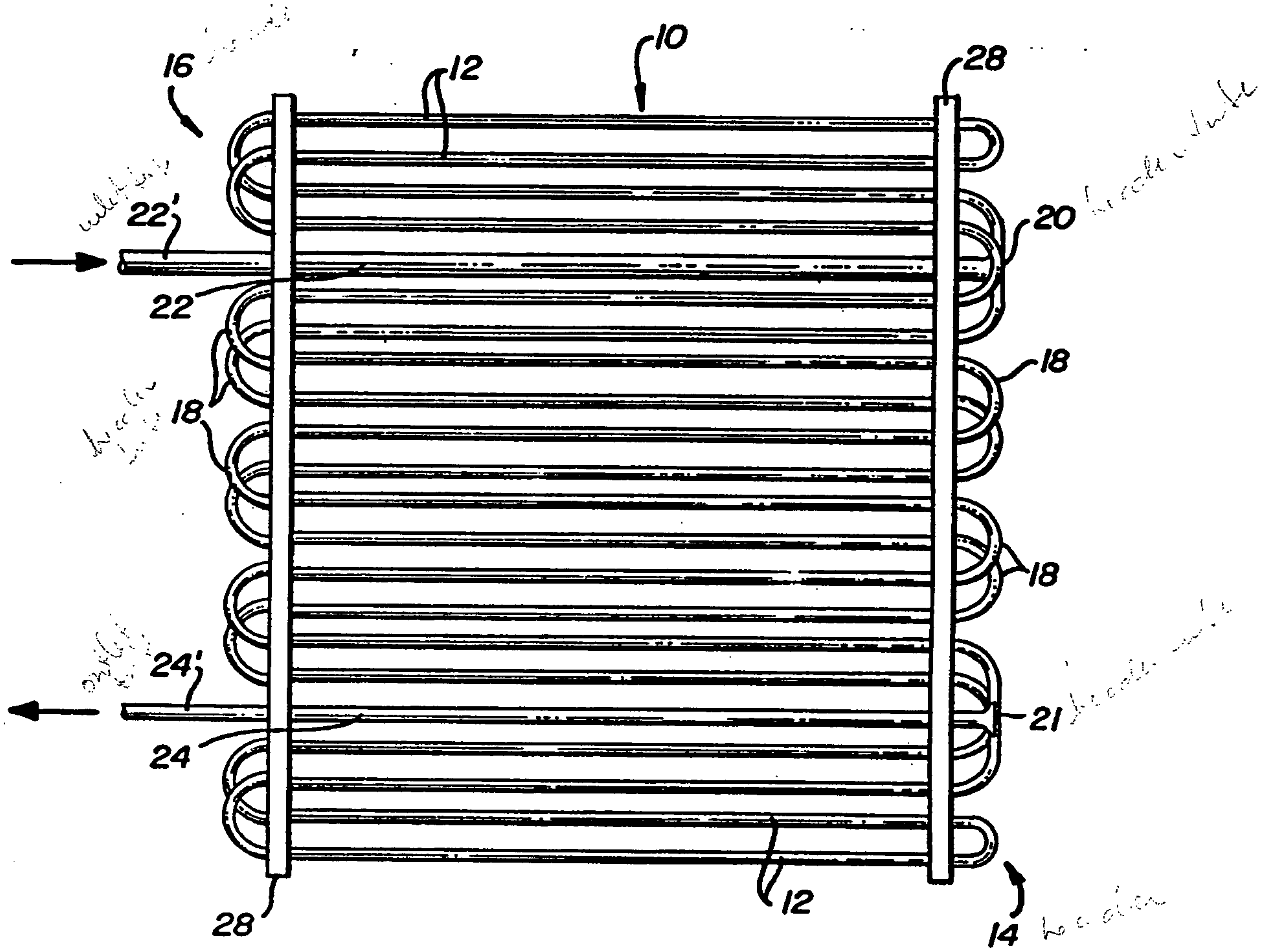
- une pluralité d'ailettes de refroidissement par convection (30) formant une rangée sur lesdits tubes de transfert de chaleur (12), lesdits tubes de transfert de chaleur (12) et lesdites ailettes (30) étant susceptibles de transférer de la chaleur entre l'extérieur desdits tubes et desdites ailettes (12, 30) et un fluide de service ou de travail en phase gazeuse ou liquide à l'intérieur desdits tubes (12);

caractérisé en ce qu'il comporte également un tube de réduction de perte de charge (22) s'étendant entre lesdits organes collecteurs (14, 16) à l'intérieur de la rangée desdits tubes de transfert de chaleur (12) et desdites ailettes (30) et relié audit ensemble d'échangeurs de chaleur, ledit tube de réduction des pertes de charge (22) présentant une surface de section transversale supérieure à la surface de section transversale de chacun desdits tubes de transfert de chaleur (12) et transportant ledit fluide de service gazeux vers et à partir dudit ensemble d'échangeurs de chaleur, et un organe tubulaire (23) reliant ledit tube de réduction des pertes de charge (22) à l'une de ses extrémités à au moins l'un desdits tubes de transfert de chaleur (12) pour transférer un fluide de service gazeux à partir dudit tube de réduction de perte de charge (22) auxdits tubes de transfert de chaleur (12) pour la condensation d'un liquide, lorsque ledit ensemble est utilisé comme condenseur, ou bien pour transférer du fluide de service gazeux à partir desdits tubes de transfert de chaleur vers ledit tube de réduction des pertes de charge (22) lorsque ledit ensemble est utilisé comme évaporateur.

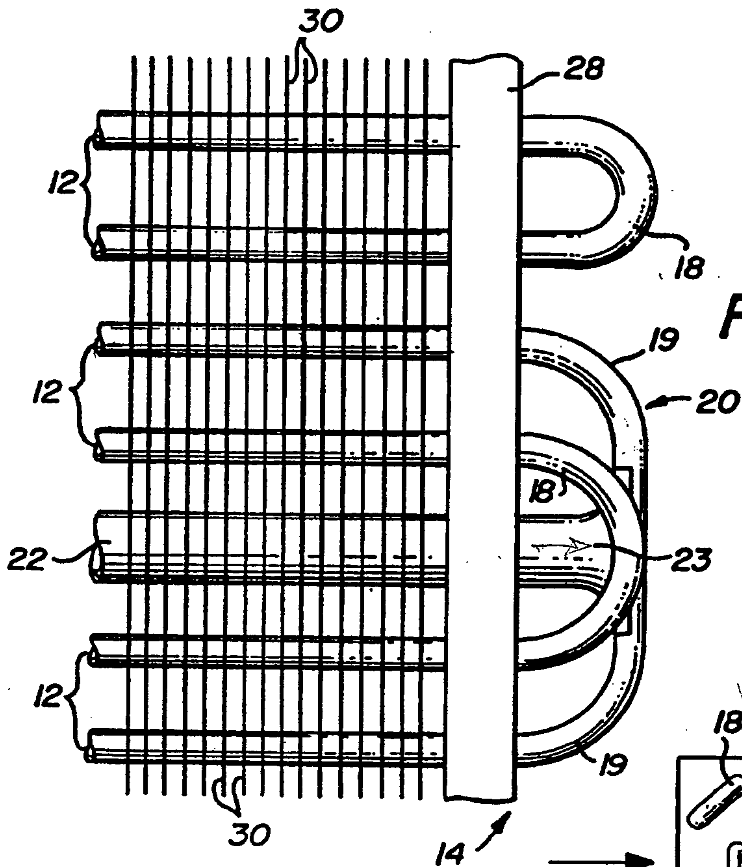
2. L'ensemble selon la revendication 1, dans lequel ledit tube de réduction des pertes de charge (22) et ledit organe tubulaire de liaison (23) présentent la même surface de section transversale.

3. L'ensemble selon la revendication 1, dans lequel ledit tube de réduction des pertes de charge (22) s'étend parallèlement à ladite rangée de tubes de transfert de chaleur (12).

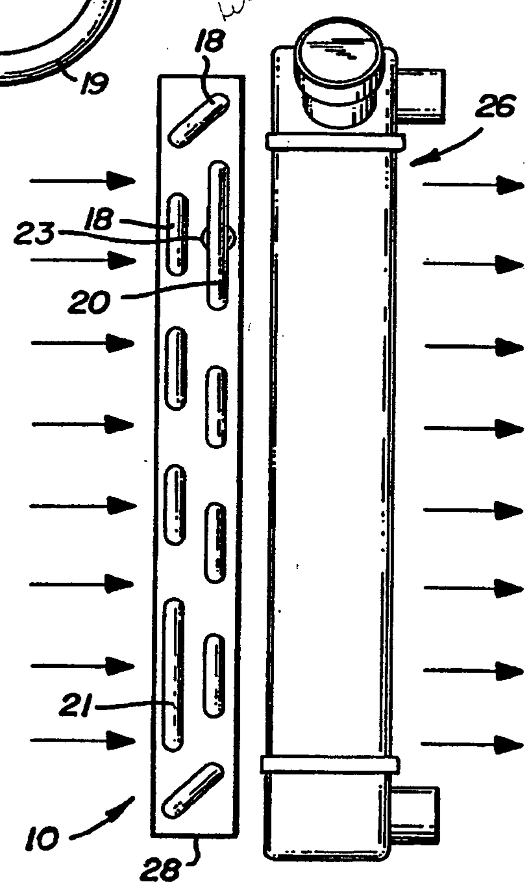
4. L'ensemble selon la revendication 1, dans lequel la surface de section transversale dudit tube de réduction des pertes de charge (22) est au moins 10% supérieure à la surface de section transversale inférieure desdits tubes de transfert de chaleur (12).



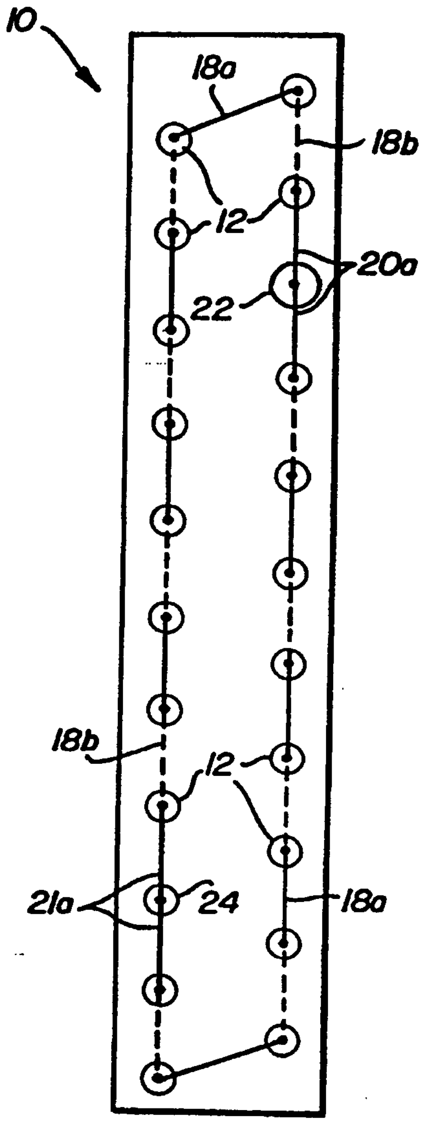
F I G. I



F I G. 2



F I G. 3


10
18a
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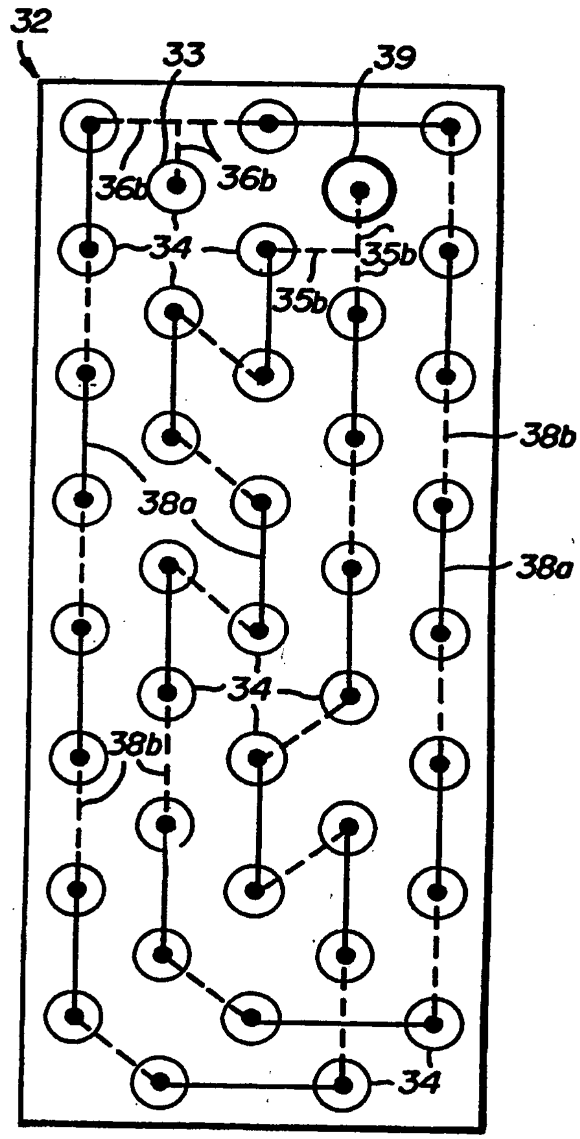
18a

FIG. 4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34

FIG. 5